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RESEARCH MEMORANDUM

for the

Signal Corps, U. S. Army

CALIBRATION OF AWS INSTRUMENT SHELTER IN LANGLEY 300 MPH 7- BY 10-FOOT TUNNEL

By John W. McKee

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NATIONAL ADVISORY COMMITTEE
FOR AERONAUTICS
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SUMMARY

Tests and calibrations of an AWS instrument shelter were made in the Langley 300 MPH 7- by 10-foot tunnel for the Signal Corps, U. S. Army. The behavior of the wind vane, the 3-cup anemometer, and the shelter cover was determined in wind speeds up to 150 miles per hour. It was discovered that the rotational speed of the anemometer was greatly influenced by the location, with respect to the wind direction, of three spacer posts that held two upper bays of instruments above the anemometer.

INTRODUCTION

At the request of the Signal Corps, U. S. Army, tests and calibrations of an AWS instrument shelter have been made in the Langley 300 MPH 7- by 10-foot tunnel. The equipment (fig. 1) consisted of 3 bays of weather-sensing elements mounted on top of a single support tube about 5 feet long. This instrument is designed for use at an untended weather station to detect weather information for radio transmittal at periodic intervals. In operation, a cylindrical cover (18 inches in diameter and 24 inches deep) is driven up and down by electric motors to expose or protect the weather-sensing elements from the weather. In the top bay was a wind vane which by means of a Selsyn drive indicated the wind direction on a remote instrument. In the bottom bay was a 3-cup anemometer driving an alternator so geared that 15.678 cycles corresponded to 1 revolution. In the center bay were additional elements that were not calibrated.

The instrument shelter was installed in the tunnel to obtain the following information:

(a) A calibration of the anemometer from 5 to 150 miles per hour (accurate to ±1 mile per hour) in terms of voltage or frequency of the alternator, with the wind approaching the instrument from various directions to determine whether structural dissymmetry influenced the calibration

(b) The wind-vane stability from 5 to 150 miles per hour

(c) The time of response of the wind vane and anemometer after lowering the cover for airspeeds from 5 to 150 miles per hour

(d) The stopping position of the cover for opening and closing operations at various airspeeds up to 150 miles per hour

(e) The amount of flapping of two electrical cables up to 150 miles per hour

(f) The simple changes that could be made to improve the operation of the instrument if it proved deficient in one or more ways.

RESULTS AND DISCUSSION

The AWS instrument shelter was mounted on a turntable with its base about 2 feet below the floor of the tunnel. The position with the terminal connectors on the base of the support tube facing directly upstream was arbitrarily designated as the angle of zero yaw. Structural limitations of the turntable did not allow a complete 360° rotation; the range of yaw angles was limited to -188.5° and 136.5° with clockwise rotation as viewed from above considered to be positive yaw. Several anemometer-cup assemblies were supplied. Assembly 3 was used for all the tunnel testing because of defects in the other assemblies. The airspeeds presented in this paper have had an estimated tunnel-blockage correction applied and are 2.2 percent higher than clear-tunnel airspeeds.

The calibration procedure was somewhat abbreviated when the instrument was found to have a variable response to the same wind velocity depending upon the direction of approach of the wind.

Wind-speed calibration.- The anemometer-driven alternator frequency was determined for various airspeeds for the zero angle of yaw. The cover was opened with zero wind velocity. The results (fig. 2) show very little scatter from a straight-line calibration of zero output at 1.5 miles per hour to 450 cycles per second at 150 miles per hour. No calibrations were obtained in terms of voltage output because the zero reading of the voltmeter that was furnished could not be maintained.

Wind-vane characteristics.- The wind-direction vane and indicator at wind speeds above 20 miles per hour had a more or less continuous oscillation of about $\pm 2^{\circ}$ from the average position of 195° on the meter. It was not determined whether this oscillation was due to vane design, wind turbulence, or general buffeting and shaking of the complete instrument. Wrapping the vane, which was flared at the trailing edge, with tape so that it was essentially flat-sided from nose to tail did not alter its oscillatory characteristics. When the shelter was tightly closed the indicator was motionless.

Response characteristics and shelter closure operation.- From limited observations it appeared that the wind vane and anemometer had reached a steady-state value in a time interval of from 0 to 5 seconds after the shelter had opened for all airspeeds. At a wind speed of about 150 miles per hour, the shelter stopped 13/32 inch higher on the opening cycle than with zero wind velocity. At a wind speed of about 150 miles per hour, the shelter stopped 1/8 inch lower on the closing cycle than with zero wind velocity. After closing the shelter at 150 miles per hour, the wind vane rotated at about 1 revolution per second, indicating that there must have been an incomplete and unsymmetrical seal condition at the top with some air movement present inside the shelter. All anemometer calibrations were made with the shelter opened with zero wind velocity. The electric-motor cables were not flapping at any airspeed; however, they were restrained at the tunnel-floor level, approximately 2 feet above the base of the instrument, and, therefore, the tunnel tests were less severe in this respect than in normal operation.

Effect of wind direction on anemometer speed and vane angle.- At a wind speed of 108 miles per hour the instrument was rotated through a total angle of yaw of 325°. As shown in figure 3, the response pattern resembles a three-lobed cam with low rotational speeds occurring for yaw-angle ranges of about 30° at the angles of yaw where one of the three spacer posts in the anemometer bay was ahead of the retreating cups. The alternator frequency was measured at a few angles of yaw with the center instrument bay filled solid by wrapping around a band of cardboard and leaving only the top and bottom bays exposed to the wind. It can be seen (fig. 3) that this modification did not improve the response pattern but did raise the general level of rotational speed somewhat.

The wind-vane position indicator had a nearly linear relation to the angle of yaw of the instrument. Wind-direction data obtained during the above anemometer calibration are presented in table I.

CONCLUDING REMARKS

From the results of wind-tunnel tests and calibrations of an AWS instrument shelter, for the Signal Corps, U. S. Army, it is seen that the rotational speed of the 3-cup anemometer was greatly influenced by the location, with respect to the wind direction, of three spacer posts that held the two upper bays of instruments above the anemometer. Further tests would be required to determine whether the variable influence of the posts could be reduced to an acceptable level by increasing their number. This approach might require that the number of posts be increased from 3 to 24 because the influence of each post is most noticeable for a yaw-angle range of 15°.

Another approach to the problem of protecting weather instruments, except for the interval when they are exposed for readings, is suggested. The shelter could have the form of a small building or shed with a door or doors that open outwardly in the roof. A standard wind-measuring instrument consisting of a wind vane and anemometer would be positioned in the shed under the door on a mechanism that would raise it through the opening in the roof. The weather elements now present on the middle bay of the AWS instrument shelter would be exposed in a similar manner, with the provision that no structure or parts be in a position to distort the wind velocity in the vicinity of the wind vane and anemometer.

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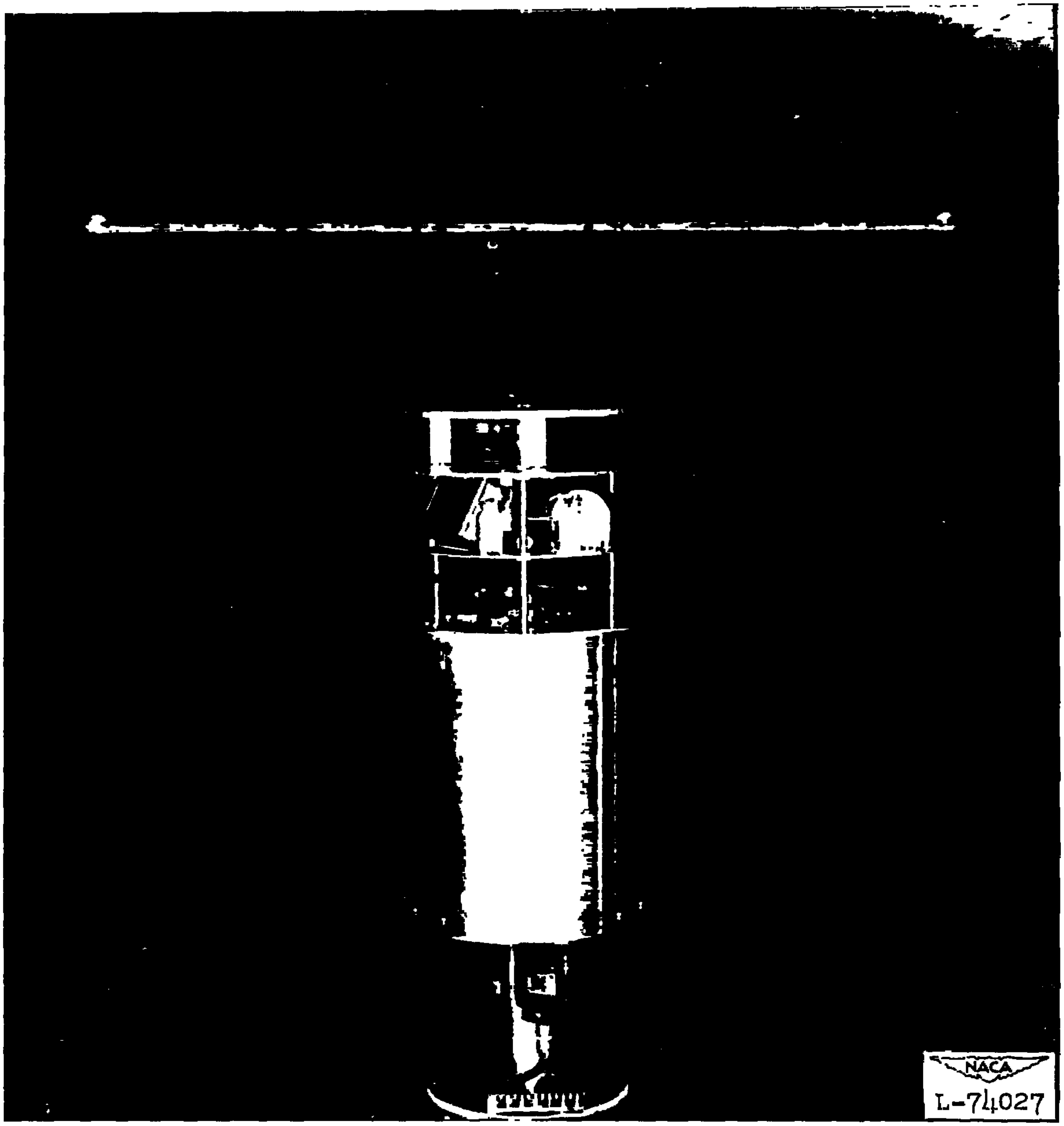
TABLE I

CALIBRATION OF WIND VANE AT AN AIRSPEED OF 108 MILES PER HOUR

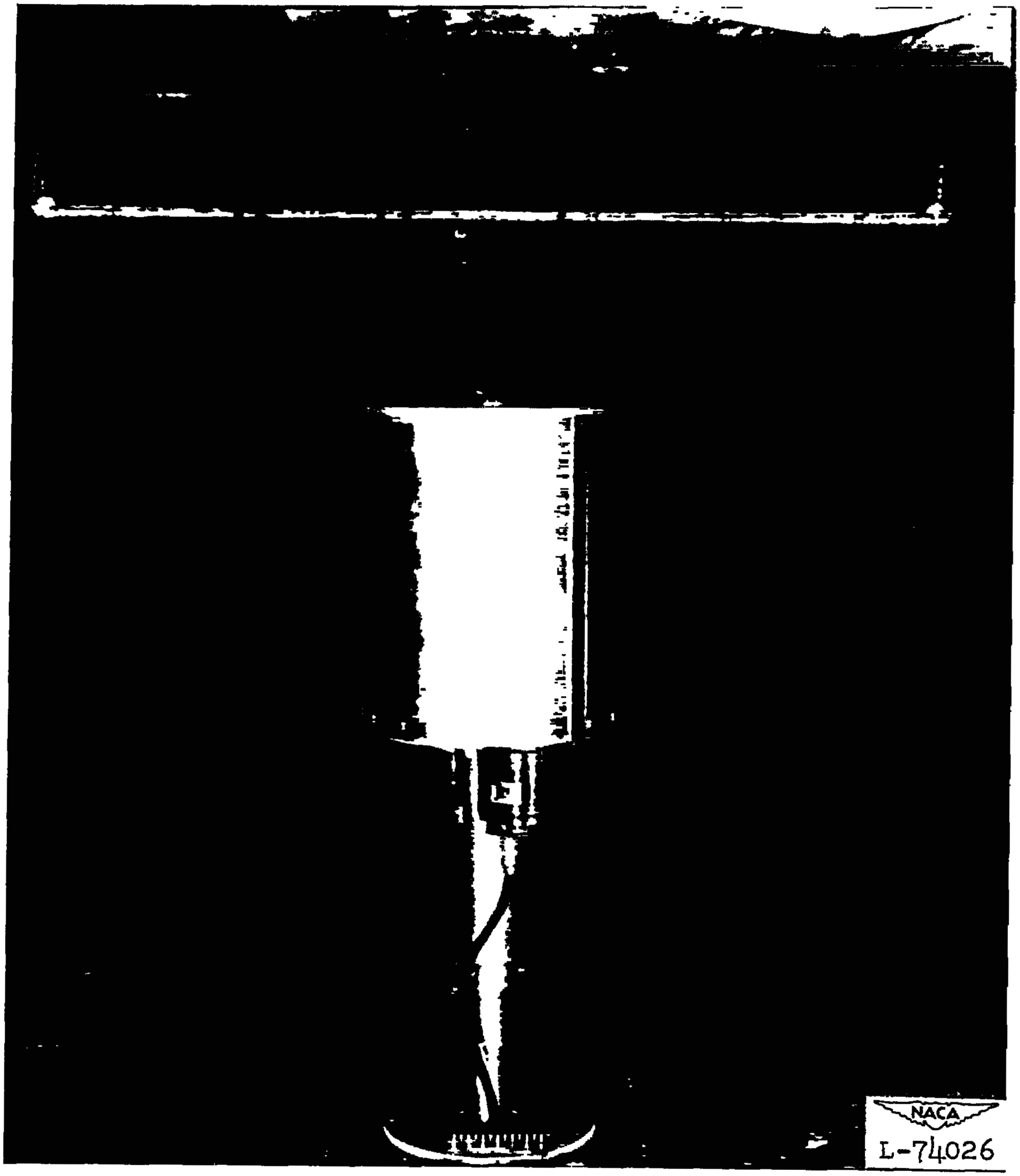
Instrument shelter, angle of yaw, deg	Wind-vane indicator, deg	Indicator deviation from linear response, deg
-188.5	23	-0.5
-180.0	15	0
[a]-180.0	15	0
-170.0	5	0
-160.0	355	0
-150.0	345	0
[a]-150.0	345	0
-140.0	335	0
-130.0	325	0
-120.0	315	0
-110.0	304	-1.0
-100.0	295	0
[a]-100.0	295	0
-90.0	286	1.0
-80.0	275	0
-75.0	271	1.0
-60.0	254	-1.0
-50.0	245	0
-40.0	235	0
-30.0	225	0
[a]-30.0	225	0
-25.0	220	0
-20.0	215	0
-15.0	210	0
-10.0	205	0
0	195	0
[a]0	195	0
10.0	185	0
15.0	178	-2.0
20.0	173	-2.0
25.0	169	-1.0
30.0	164	-1.0
40.0	153	-2.0
50.0	144	-1.0
60.0	134	-1.0
70.0	124	-1.0
75.0	120	0
80.0	115	0
90.0	104	-1.0
100.0	95	0
110.0	84	-1.0
120.0	74	-1.0
130.0	64	-1.0
136.5	56	-2.5

[a]Center instrument bay filled solid.



(a) Shelter open.

Figure 1.- Signal Corps "AWS Instrument Shelter" installed in the Langley 300 MPH 7- by 10-foot tunnel. Zero angle of yaw.



(b) Shelter closed.

Figure 1.- Concluded.

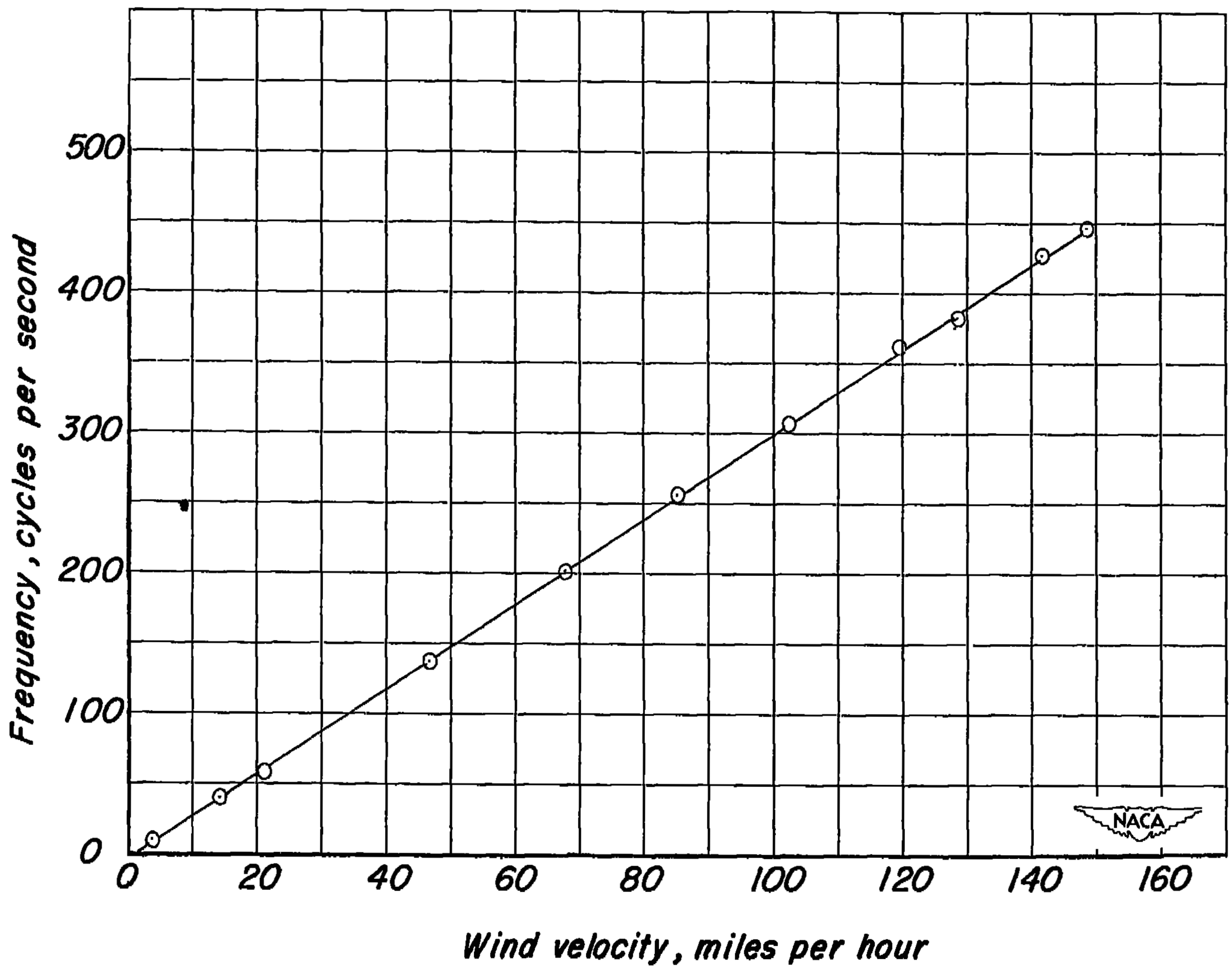


Figure 2.- Variation of the alternator frequency with wind velocity for the AWS instrument shelter using anemometer-cup assembly 3. Zero angle of yaw.

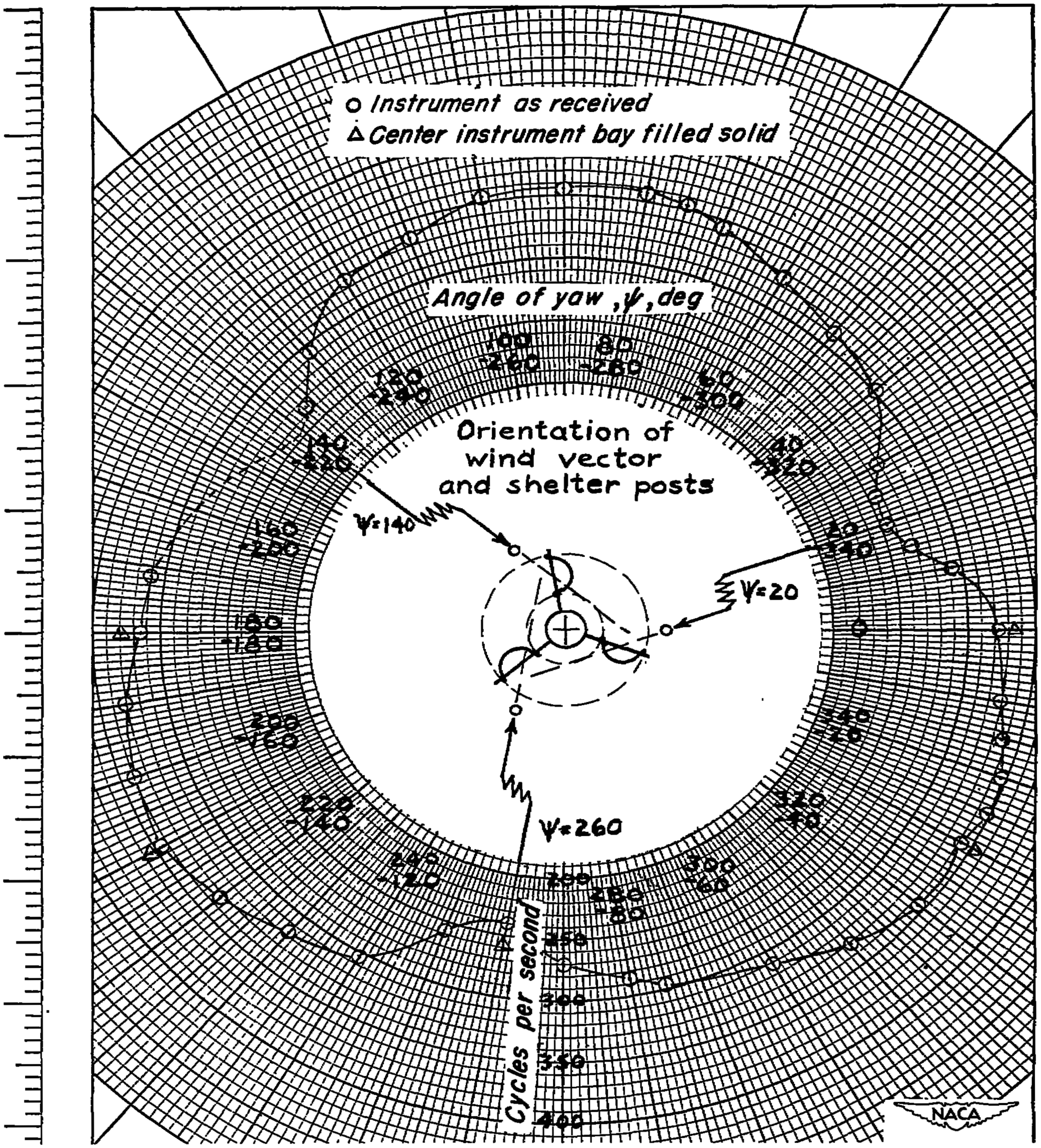


Figure 3.- Effect of angle of yaw of the AWS instrument shelter on the anemometer alternator frequency. Wind velocity of 108 miles per hour; cup assembly 3.